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Spectroscopy of Circumnuclear Star Forming Regions in Early Type Spirals

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1. Abundances

We present spectroscopy observations of circumnuclear star forming regions (CNSFRs) in the galaxies: NGC 2903, NGC 3351 and NGC 3504, all of them of over solar metallicity according to standard empirical calibrations. Using data of moderate resolution a detailed determination of their abundances is made after careful subtraction of the very prominent underlying stellar absorption. A two-component (emission and absorption) Gaussian fit was performed in order to correct the Balmer lines for the underlying absorption.

Because of the low excitation of the regions it is not possible to detect the auroral [OIII] $\lambda\,4363$ Å necessary for the derivation of the electron temperature. It is therefore impossible to obtain a direct determination of the oxygen abundances and empirical calibrations have to be used instead. CNSFRs show values of O_{23} (=([OII]3727+[OIII]4959,5007)/Hβ; Pagel et al. 1979) which indicate oversolar metallicities, but the actual values are difficult to estimate since O23 levels off. At times [OIII] lines are very difficult to measure. The combined parameter S_{23}/O_{23} (S_{23}= ([SII]6717,6731+[SIII]9069,9532)/Hβ; Vílchez & Esteban 1996) yields values of the oxygen abundances higher than twice solar. Also the N2 parameter (log([NII]/Hβ; Denicoló, Terlevich & Terlevich 2002) renders oversolar abundances. Furthermore, the CNSFRs of our sample show the highest values of the ratio N/O known for HII region-like objects. It is found that most regions show the highest abundances in HII region-like objects.

Parametrising metallicity *vs.* ionisation degree by [SII]6717,6731/[SIII]9069, 9532 we find that our CNSFRs are among the HII region-like objects with the lowest ionisation parameter. The temperature of the ionising stars can be parametrised by the "softness parameter" η' (=([OII]3727/[OIII]4959,5007)/([SII]6717,6731/[SIII]9069,9532); Vílchez & Pagel 1988). This parameter can be used as an ionising temperature indicator. Analysing N2 vs. η' we find that the CNSFRs of our sample have, in general, lower values of η' than those of the GEHRs, implying higher ionising temperatures.

2. Masses

We have measured gas and stellar velocity dispersions in 5 CNSFRs and the nucleus of the barred spiral galaxy NGC 3351. The stellar dispersions have been measured from high resolution spectra of the Ca II $\lambda\lambda$ 8494, 8542, 8662 Å triplet lines (CaT), while the gas velocity dispersions have been measured by Gaussian fits to the Hβ λ 4861 Å and [O III] λ 5007 Å lines on high dispersion spectra. Stellar velocity dispersions are between 46 and 76 km s^{-1}. Stellar and gas velocity dispersions are found to differ by about 20 km s^{-1} with the Hβ lines being narrower than both the stellar lines and the [O III] λ 5007 Å lines. However, the best Gaussian fits involved two different components for the gas: a "broad component" with a velocity dispersion similar to that measured for the stars, and a "narrow component" with a dispersion lower than the stellar one by about 30 km s^{-1}. When plotted in a [O III]/Hβ *vs* [N II]/Hα diagram, the two systems are clearly segregated with the narrow component having the lowest excitation and being among the lowest excitation line ratios detected within the SDSS dataset of starburst systems.

The CNSFRs, with sizes of about 100 to 150 pc in diameter, are seen to be composed of several individual star clusters with sizes between 1.7 and 4.9 pc on the F606W WFPC2-HST image. Using the stellar velocity dispersions, we have derived dynamical masses for the entire star forming complexes and the individual star clusters. Dynamical masses for the whole CNSFRs are between 4.9×10^6 and 4.34×10^7 M$_\odot$ for the CNSFRs and 3.5×10^7 M$_\odot$ for the nuclear region inside the inner 11.3 pc, and between 1.8 and 8.7×10^6 M$_\odot$ for the individual star clusters.

Masses of the ionising stellar clusters of the CNSFRs have been derived from their Hα luminosities under the assumption that the regions are ionisation bounded and without taking into account any photon absorption by dust. Their values are between 4.1×10^5 and 2.42×10^6 M$_\odot$ for the starforming regions, and 3.1×10^5 M$_\odot$ for the nucleus. Therefore, the ratio of the ionising stellar population to the total dynamical mass is between 0.01 and 0.11. Derived masses for the ionised gas vary between 3×10^3 and 8.6×10^4 M$_\odot$ for the CNSFRs, and 1×10^3 M$_\odot$ for the nucleus.

We determined the line of sight stellar velocity along each slit. The rotation velocities derived for both stars and gas are in reasonable agreement, although in some cases the gas shows a velocity slightly different from the stars. The rotational curve corresponding to the position going through the centre of the galaxy shows maximum and minimum values at the position of the circumnuclear ring.

References

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